Generalised Media of Interaction and Abstract Resources: Two Concepts on Social Control derived from Sociology and Computer Science

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1 Abstract

In this paper, we present a two-fold view on how software agents cooperate and thereby produce some sort of social structure. First, we compare sociological and Computer Science-based models of actors and agents. Then, we introduce two distinct approaches, one from Computer Science and one from Sociology, namely **Abstract Resources** and **Generalised Media of Interaction.** Both consider how local interactions between agents can be described and installed in order to interact in an efficient and stable way. The former concept considers the problem of survival in a physical environment while the latter focuses on social interactions. To exemplify these approaches we instanciate them to a common scenario: the Settlers' World.

The main contribution of this work lies in the presentation how both, strong and weak Socionics can profit from a common use of both concepts, i.e., how the use of Generalised Media of Interaction can be realised to optimise distributed systems and how Abstract Resources can be used to implement Parsonian interaction patterns.

2 Introduction: Actor and Agent Models

There is a vast amount of differing definitions of what an agent or an actor is; hence, we shall first define explicitly what we conceive of as the relevant features of acting entities. In Parsonian Sociology one finds the notion of an goal-oriented actor, see e.g. (Parsons 1969). This sociological definition will be compared to various definitions of agency in Computer Science.

Parsons takes the actor to be an **agent** that has **goals**. An agent is an individual that shows behaviour. **Behaviour** is the capability to change the state of the world. The world can be divided into the agent itself and its environment. The environment, as it is perceived by the actor, defines the **situation** the actor is in. A goal is a certain state of the world. To **act** means to behave according to a goal. In general, an actor can choose from a set of optional actions, about which it has specific expectations in which way they will change the world. The actor selects a specific action from its options according to its goals, the means at its disposal and its situation. Actors use a shared **language** in order to communicate with one another.

This basic definition, which, in due course, will be expanded to the definition of a social actor will now be compared to definitions of an agent/actor from Artificial Intelligence:

In their textbook on AI (Russell, Norvig 1995) define an agent as follows: "An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors." This is a very broad definition of the term agent and can eas-

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ily be identified in the social definition, as made above. The main characteristics of this definition is the distinction between agent and environment, and the capability of the agent to relate to its environment. Clearly, this is necessary for a Parsonian actor, but not sufficient.

A description of what an agent is, has also been put forward by (Wooldridge, Jennings 1995). They characterise an agent by the following traits:

- *Autonomy*: Agents control their actions and internal states to enable them to operate without the direct intervention of humans or others.
- *Social Ability*: Agents communicate with other agents by using some kind of agent communication language.
- *Reactivity*: Agents respond to changes in their environment which they can perceive.
- *Pro-Activeness*: Agents are able to perform goal-directed behaviour in addition to reaction to their environment.

This more elaborated definition of an agent's abilities compares to the Parsonian actor as follows:

- *Autonomy*: This part of the definition of agency is hard to compare to social agency, since it is about internal states, which are of interest to the social analysis only as far as they concern social action. However, the distinction between the agent and its environment is again prominent in the definition.
- *Social Ability*: The ability to draw on functioning communication is also crucial to the Parsonian actor. Although it is indeed a social ability it is exactly the point of Parson's Generalised Media of Interaction to add new means to structure interaction other than language, which is taken as a necessary precondition, though.
- *Reactivity*: This is included in the Parsonian actor's ability to select actions according to, at least: also, its situation.
- *Pro-Activeness*: This exactly mirrors the definition of action as presented by Parsons.

Concluding one might say, that this AI-definition includes many, though not all, of the ingredients of the Parsonian actor. On the other hand, some aspects (e.g., autonomy) are left out on the Sociology side. Since concepts occur in both sciences, but come under different names, a comparison seems to be worthwhile. It is also crucial to notice that AI traditionally likes to draw on ideas which do relate more closely to psychology, like internal states and processes of an agent. This does not come as a surprise since there is cognitive science as a psychological approach that seizes heavily from AI-methods.

AI Researchers have adopted stronger and more specific definitions of agents, usually in the context of agents they have modelled and/or implemented. (Cohen, Levesque 1990) define their agent with human mentalistic notions, such as knowledge, belief, intention and goals. They orient this theory after M. Bratman's well-known requirements of an intelligent agent's mental capabilities (Bratman 1987). This so-called BDI-theory elaborates on the idea to put more of the agents capacities into its internal structure. So it goes even further towards a psychological modelling of agency. It is questionable whether this is necessary or helpful if one tries to model sociological concepts.

From a more abstract point of view, there is a fundamental distinction between an agent in Computer Science and the agent as it is described in Sociology. It stems from the different approaches the two sciences take towards their subject matter: Computer Science constructs its agents and has immediate control over their abilities while Sociology can only describe the typical features of an (ideal) agent it has to accept as given.

Also, the concrete real world adds to agency an infinite number of possible dimensions of behaviour an agent can show, while an abstract software agent only has as many options as the software designer gives to it.

In the first place it is important to note that the definitions of agency can be compared to the sociological definition at all. So one would hope that it is also possible to find an **adequate** match or intersection of the two approaches to define agency. Whether the deeper differences really destroy any possibility of an adequate comparison must be left as an empirical question. If sociologists eventually find the capabilities of a software agent for good reasons unsatisfactory the idea of micro-simulation of social action will be in severe trouble.

Now that we have elaborated how actors and agents are related, we can proceed to present and compare the approaches of Generalised Media of Interaction and of Abstract Resources. The remainder of this paper is structured as follows: First, we briefly describe the application domain: the Settlers' World scenario. In Sections 4 and 5, the two concepts of Generalised Media of Interaction and Abstract Resources are presented, followed by a comparison and a discussion on their usefulness for weak or strong Socionics. Finally, we conclude by comparing the concepts and by pointing to future work.

3 Application Domain: The Settlers' World

In this section, we outline an application domain which is on the one hand suitable to illustrate the concepts of Generalised Media of Interaction and Abstract Resources in an artificial society. On the other hand, the domain is simple enough to be simulated on the computer using multi-agent techniques. Therefore, the term „agent" can be used in a two-fold manner: it can represent an acting entity in the social domain and it can refer to the technical element in the simulation program. For the remainder of this section we use it in the first way, while we show in section 5 how to realise our concepts in an agent-oriented programme.

The Settlers' World scenario reflects a "situated society": a collection of individuals is exposed to an unknown environment in order to build up and live in colonies. The environment offers raw material sources of various kinds. Colonists have to process them in order to produce groceries to be consumed and to build up settlements, means of transportation, etc. The environment may also provide threats to colonists, e.g., natural disasters may occur or predators may exist.

Colonists have unique skills to perform certain jobs; they have some sort of "life energy", which illustrates their physical constitution: if it is decreased to 0, the individual has died. Any activity an agent performs results in energy loss. The colonists' main goal is to keep their life energy as high as possible. Increasing energy is achieved by consuming food. Specialisation and cooperation between settlers is reasonable because the process of producing food can hardly be achieved solitary.

In order to optimise efficiency, in this model settlers can specialise on certain jobs according to their various skills. In addition, they can develop organisational structures ranging from strict hierarchies to more flexible shapings, for instance based on voting mechanisms. Colonists can decide whether or not to join or leave a certain groups.

4 Generalised Media of Interaction

The concept of Generalised Media of Interaction is only a fragment of the rich Parsonian theory of society. After a very short sketch of this concept we will try to formalise it in order to put it into computer-code. The local level will be given priority while almost completely neglecting higher levels of society (like the subsystems of society). The crucial problem at stake here is: *how can an actor Ego control the actions of an actor Alter so that Alter acts according to Ego's intentions?* To this end both interaction-partners need in the first place clear-cut expectations how the other actor will act.

4.1 Introduction

Parsons introduced the problem of how two actors, completely unknown to each other, manage to interact with one another so that they eventually act in a coordinated manner. This problem is often referred to as the problem of **'double contingency'**. Since we have a lot of knowledge about the historically evolved world we live in, this problem never actually occurs: Even when we meet a complete stranger in the street we can still assume many features of that person to hold true. Still, the general problem remains how interaction partners establish complementary expectations about one another's future actions. Generalised media of interaction solve this problem and provide actors with applicable strategies.

One way to solve this problem would be to talk about coordinated actions. Ego and Alter might simply discuss the things they will do in the future. This assumes that communication is possible between the actors, which generally includes shared language. This implies a **generalised use of symbols** with selective reference to the world. It is thus possible to talk about specific things, which are not physically present. Symbolic and generalised communication widens up the range of topics while, at the same time, losing obvious evidence of statements. When one uses language one needs to trust each other that the made statements are reliable and compatible.

In this sense Generalised Media of Interaction are **specialised languages**: They are symbolic references, i.e. one cannot use the medium itself. A medium is useful only in as far as it refers to something else and is accepted by others. It is based on generalised assumptions about when and how one is supposed to use it. It implies specific selections about how to observe the world: Things can be expensive, effective, true or good. In contrast to ordinary language Generalised Media of Interaction transport along with them specific motivations why Alter should accept the selection made by Ego. Whereas it is not obvious how Ego can systematically make Alter to do what Ego aims at in the case of plain language. Here, the art of rhetorics would come into play. Generalised Media of Interaction turn this *art of control* into a reliable *control-technique*.

By making two analytic distinctions Parsons identifies four strategies that can be used in the interaction to control the other's actions, namely **money, influence, power** and **commitments**. They are all based on the idea to be able to **sanction** the actions of another actor. The different media of interaction can be distinguished according to their **channels of control**, which go along with the definition of an intentional actor being aware of its situation. Consequently, the four media of interaction derive from the combinations of Ego *sanctioning positively or negatively* the reactions of Alter to changes induced by Ego of Alter's *intentions or situation*:

Control Channel Type of Sanction	Situation	Intention
Positive	inducement/money	persuasion/influence
Negative	deterrence/decision-power	activation of commitments commitment generalisation

Accordingly, an actor has the following social interaction abilities: it can give money, influence, take a collectively binding decision or commit itself to some value.

In the use of Generalised Media of Interaction the symbolic references turn the problem of trusting an interaction-partner into trusting the validity of the medium. The interaction is freed from the need to negotiate the issue of trust every time anew. Instead, trust needs to be put into the **institution** of the generalised medium. An institution is a complex of normative rules and principles which control social action via law or other social mechanisms. Organisations (banks, parties) process the implementation of legitimate use of media via social institutions (property, authority). These social structures thus become necessary prerequisites for the smooth functioning of local interactions.

4.2 Formalisation

The use of Generalised Media of Interaction needs to be formalised, in order to serve as a guide for interaction in a Multi-Agent System (MAS). The following pseudo-code of the interaction protocol might help to understand how to put this description into a computer-system.

Ego ⇒ Alter : communicate [perform(action) , use(medium)] proposal

Alter ⇒ Ego : communicate [perform(action) , use(medium) , 0/1] acceptance

The terms '**use**' and '**perform**' both refer to the execution of an action. '**Action**' stands for some desired optional action an actor can perform. '**0/1**' symbolises Alter's denial or acceptance of Ego's proposal respectively.

In the interaction it is not necessary that Alter's reaction is sanctioned by Ego itself. It is also possible that other actors come into play. It is crucial, though, that many actors take part in the circulation of the media. The next steps in the interaction are the following:

Medium	Social Interpretation of its Use	Action	Social Interpretation of the Action
Money	Give Alter money	if 0 then <nil>	If Alter rejects, Ego and Alter do nothing
		if 1 then ▪ Ego: use(medium) ▪ Alter: perform(action)	If Alter accepts, Ego gives Alter money and Alter: ▪ decides towards Ego's goals ▪ produces support for Ego ▪ commits to Ego's goals (work-relation)

Medium	Social Interpretation of its Use	Action	Social Interpretation of the Action
Power	offer collective decision -power to Alter	if 0 then ▪ Ego: use(medium)	If Alter rejects, Ego worsens Alter's situation – (punish)
		if 1 then ▪ Alter: perform(action)	If Alter accepts, he ▪ gives Ego money ▪ produces support for Ego ▪ commits to Ego's legitimisation
Influence	support Alter	if 0 then <nil>	If Alter rejects, Ego and Alter do nothing
		if 1 then ▪ Ego: use(medium) ▪ Alter: perform(action)	If Alter accepts, he ▪ gives Ego money ▪ decides towards Ego's goals ▪ commits to Ego's reputation Ego ▪ supports Alter by approving to its wisdom
Commitment	offer value-commitment to Alter	if 0 then ▪ Ego: use(medium)	If Alter rejects, Ego disapproves to Alter's actions
		if 1 then ▪ Alter: perform(action)	If Alter accepts, he ▪ gives Ego money (work-relation) ▪ decides towards Ego's goals ▪ supports Ego's commitments

Additionally to the exchange of media Alter can give physical, i.e. not: social goods to Ego. This is to be thought of as a sink of the cybernetic social system that is established by the Generalised Media of Interaction.

Some further points have to be made so that one can see how Generalised Media of Interaction can possibly be implemented:

- **Knowledge**
  Both aspects, how media are being used and what can be negotiated in a specific medium need to be known to an actor. What exactly can be negotiated in a certain medium can vary. In some societies one can buy a husband for example, in some one cannot. So every medium in a society has a reference list of possible negotiable objects. Actors generally know this list.

- **Spending a Medium**
  Actors can spend the media they possess legitimately to control others. Once Alter does something because of Ego's use of a portion of a medium, this portion is attached to that specific motivation and cannot be removed. Alter in turn can use the medium to control others, so that other actors will be important in processing the medium.
- **Zero-sum-process?**
  In order to keep the exchange of media running, actors must gain media in the future when spending their current media. Passing through intermediary states it is possible to change the total amount of a medium. A typical case would be to use influence to control the power-system so that more influence is gained. This is what happened when green pressure-groups managed to establish themselves as a proper party, which is taken to have a high reputation in green problems.

4.3 Application

We use the sociological concept of Generalised Media of Interaction to study the effects in organising the social interactions in Settlers' World, as outlined above. For getting started it seems to be appropriate to use a limited set of actors with various media at their service. The use of Generalised Media of Interaction is implemented as a symbolic act without the exact details of a pseudo-physical description of the particular process of, e.g. exerting power. This can be incrementally added in further work, though.

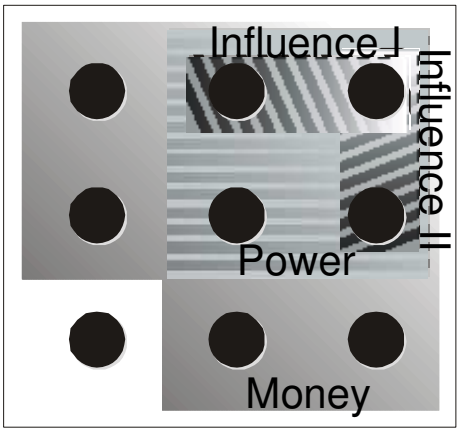

Figure 1: A Set of Actors with Possession of Media

Our minimal Settlers' World consists of nine actors. It includes a money and power system, which have heterogeneous media distributions. In this small scenario the decisions taken by powerful actors are binding for all actors. Two influence collectivities, like e.g. well-reputed scientists and elder-statespersons are also present.

All but one actor (an almost complete social drop-out) take part in the exchange of money. Four actors are related to one another in a hierarchical power-relation. There are two influence collectivities with two members respectively. One of these is part of both influence collectivities. Eventually the whole system shares latent commitments to valuing the legitimisation of the power system, to being loyal to the influence collectivities and to general values about non-social actions. Figure 1 shows the correlations.:

The whole system of actors will, in the ideal case, process a growing amount of media that will be useful in order to enable the system to persist. When actors have different goals it should be observable that those actors which have the most media at hand also have the best chances to reach their goals. The more media an actor has legitimisation to use, the more it can work on arranging positive feedback-cycles that supply it with sustained control-resources. So one should expect that actors with power and influence at their service should be able to systematically increase their ability to control others. Whereas those actors who can merely use money will typically be left to regulate their expenditures having no chance to provide for a self-induced increase in media.

5 Abstract Resources

While we have presented a concept from Sociology in the previous section, we now introduce an AI-based concept which has been developed to explicitly represent interdependencies between agents enabling them to reason on these resources.

5.1 Introduction

To represent such interdependencies, we regard an abstract resource as a limited set of items for which agents solvers apply. The task therefore amounts to decide about the distribution of the items. This happens by determining disjoint subsets of the abstract resource to be allocated either for own use or for other problem solving agents.

A rather primitive example of an abstract resource is a unary set which corresponds to the well-known construct of a **semaphore** in Computer Science. This restricts certain activities that apply for the semaphore to happen in a sequential manner, as only one of them is able to get a hold on it and therefore allowed to compute (internal use) or act (external use). The semaphore also illustrates the higher-level character of resources since it does not restrict the detailed computation within the confirmed activity. Rather, it is a representation of a selected subspace of allocations for the concrete resources; assigning an abstract resource thus amounts to putting 'guidelines' or constraints on the behaviour of associated agents.

5.2 Optimising An Agent Society

Since the area of Multi-Agent Systems has derived from Computer Science, there is the inherent endeavour to optimise a computer system in general, and a MAS in this special case. To approximate the optimal agent society, a straightforward though by no means trivial approach is to introduce a social hierarchy which consists of agent layers, individual agents, groups[3], and the society (Figure 2) as explicit **decision stages**.

The content of any adaptation decision on a particular macro-level stage, but also agent-internal stage is the resource assignment to members of the subordinate stages, based on their performances. On the macro-level stages, several options remain to actually implement the resource assignment procedure: Distributed approaches realise a common social stage purely by communication protocols and the inherent distributed decisions. More centralistic approaches either totally replace the former individual agents by a new agent or they introduce a so-called **representative agent** being a selected or fresh member of a group. We take the latter approach of representative agents because on the one hand, it avoids the communication overhead of a fully distributed setting and on the other hand, it keeps the possibility of a dynamic reconfiguration which is challenging if one chooses the replacement option. The representative agent achieves an efficient structure of its social stage through performance monitoring and resource allocation; the same allocation mechanism can hence be employed for both the micro- and macro-level resource distribution. This concept supports the design of social structures that are dynamically created and modified where useful.

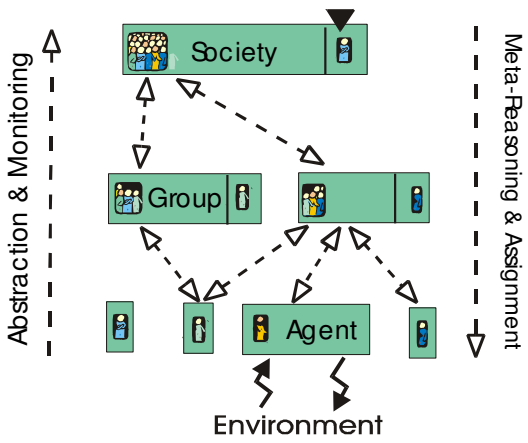

Figure 2: Layered Structure of a Society

[3] In our scheme, groups consist of arbitrary mixtures of agents and subgroups.

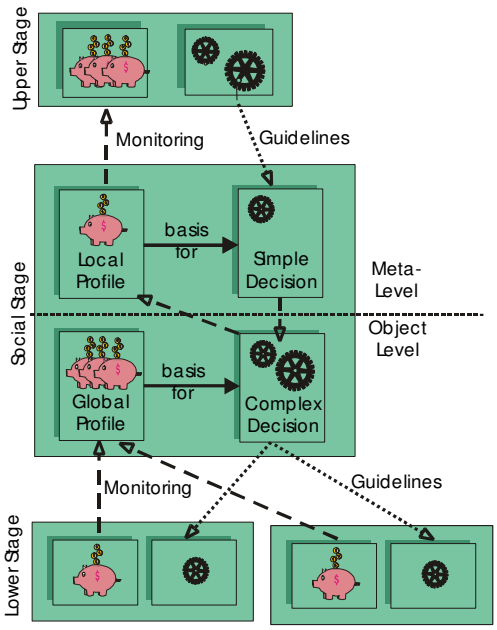

Figure 3: Resource Assignment Mechanism

Based on abstract resources, we are able to develop a two-fold allocation procedure to be integrated on **every** stage that monitors the performance of lower stages and sets up guidelines for the still autonomous behaviour of the lower stages. As Figure 3 illustrates, we integrate the complementary advantages of a complex and optimal search by a **decision-theoretic planning** approach (which approximates to the optimal problem solution) and of a fast and flexible mechanism, the **steepest ascent** method (which finds local optima). At each social stage, the complex decision making is directed by the simple decision making as its meta-level. As a result, our social hierarchy is a dynamic trade-off between tractability and optimality which does not stick with the restrictions of Russell and Wefald's original Meta-level architecture. More details on this mechanism can be found in (Gerber, Jung 1998).

5.3 Application

For the scope of this paper, we focus on a very narrow aspect of the Settlers' World domain:

Suppose we want to simulate an agricultural society where most of the individuals are farmers. For the sake of simplicity we reduce the scenario: Only a dozen farmers and a mayor exist in that particular society. The farmers can produce three kinds of grain which they need for their own consumption, but also for trading with other societies for goods they cannot produce. Furthermore, a currency has been established. The three grain types can be sold for different prices. Again, for reasons of simplicity we assume equal production costs making the sales profit of a product only dependant on its price. Obviously, under these conditions, every farmer prefers to produce only the most profitable grain (except maybe, for private consumption).

Further assume that the environment our society lives in, is highly vulnerable against massive unbalanced exploitation of the environment. Under such conditions however, a rational farmer would still produce only the most profitable grain, since he knows that first, he only contributes a rather small portion to a potential ecological damage, and second, if he modifies his farming plan towards a more balanced production, other farmers most likely will take over his market share and produce even more of the most profitable grain. This local optimisation will eventually lead to a global disaster.

In such a case, central control is needed: for the sake of global welfare, the mayor has to spread guidelines on the production of the most-wanted good. However, depending on the current ecological situation of the environment (which also depends on global influences such as heat waves, thunderstorms, etc.) he or she can tighten or relax the guidelines.

In this scenario, the mayor is represented by a special agent, the so-called **monitor agent.** With the technique described above, the monitor agent can control the distribution of the abstract resource **"***Production of a certain amount of the most profitable type of grain***".**

The system is initialised with a society configuration the user has inserted prior to the run of the simulation. All farmer agents perform their tasks, i.e., they collect and process raw material, consume food, etc. After a time interval the monitor agent scans the state of its group in order to receive information about the current production. The monitor agent now computes a local step in the configuration space taking into consideration the difference in the grain production, the previous move and a possible desired goal state of the society.

6 Comparing Generalised Media of Interaction and Abstract Resources

We have presented two concepts, Generalised Media of Interaction and Abstract Resources, stemming from two sciences, Sociology and Computer Science. In order to clarify our ideas, we have related both concepts to a common domain, the Settlers' World. Now we compare them to show how one concept can be used to implement or refine the other.

There seem to be three major points where one would like to see how the two concepts relate to one another: the notion of optimality, hierarchical structures and central control. Differences might point towards new conceptual possibilities and similarities might suggest chances to unify the approaches so that the computer system can be used as a simulation.

As pointed out earlier, **optimality** is a criterion for systems developed in Computer Science. It denotes the maximisation (or minimisation) of an implicitly or explicitly defined function of the system: The farmers should produce as much as possible without seriously hurting the environment. From the perspective of society this is an external criterion, since it takes items from the physical environment as relevant measures. In the case of Parsonian Sociology one does not want to define a proper optimality criterion. However, there is also the idea of a modern, 'fully developed' and functioning society. This implies that media show many features similar to the ones that money shows, which is taken as the defining standard of a medium. Also, it is preferable for a medium to fluctuate freely and in decent quantities. This means that society (whether one chooses to call it 'modern' or 'optimal') has internal points of reference. Both approaches assume persistence of society, though.

Eventually in both concepts one finds the idea to have a means to **centrally control** whole groups of agents. This is done either in an explicit fashion: Assignment of resources and monitoring of success of the agents' activities by higher level agents. Or it is introduced as the existence of social institutions, which regulate the legitimate use of media and which are widely applicable rules. The point here is that central organisation is involved (jurisdiction, executive organisations) but not sufficient. Local actors have to obey centrally supported rules. Also, it is not obvious how formal rules grow out of actors' actual behaviour. Monitoring of actors' behaviour and institutionalisation of rules accordingly should serve as a general framework for a process that can be described in more detail.

For Abstract Resource allocation in a MAS it is crucial to introduce a **hierarchical structure** that allows higher levels to control the amount of resources available to lower levels. To this end one uses representative agents that monitor and assign resources of lower levels. Parsons introduces higher system levels as the appropriate way to study society. This does not, however, necessarily imply representation as speaking and acting in responsibility of a group. However, this is a point that calls for clarification in future work in more detail.

7 Perspectives on strong Socionics

The key for how to use Abstract Resources for purposes of Sociology is to investigate how Abstract Resources can be used to implement Generalised Media of Interaction.

The concept of Abstract Resources as it is introduced in the previous section seems to offer valuable possibilities for an implementation of Generalised Media of Interaction. It must be noted, though, that a transformation of the computer scientific concept needs to be done, if one aims to construct an adequate mapping of Parsonian theory on the computer: The most attractive aspect of the concept of Abstract Resources is the link between the micro-level of interaction and higher or macro-levels. The direct representation of a group by a representative agent, that monitors and assigns resources, could be turned into a fixation of the practice of a collectivity into formally stated rules. Monitoring and Assignment could serve as names for methods that perform this rule-formulation in variable ways. Thus institutionalised rules would then be applied by actors in the practice of social interaction.

There is a specific problem that surfaces in a simulation-study of sociological theory. It is due to differences between Sociology and Computer-Science as historically incompatible disciplines. Following (Simon 1981) one can view Sociology as a science that analyses society, whereas Computer Science is predominantly occupied with the construction of technological concepts. This distinction makes computer simulation of social reality problematic: Sociological theory can point out typical or average behaviour which in an empirical case may look very different. The systems that computer scientists construct, however, are obligatory for the way the computer runs. As long as the hardware works properly, violations of the rules set up by the programmer are impossible. This issue is also relevant here, since the interaction-protocol, introduced above, does not allow for violations. There may be various stages how one might want to introduce violations of this protocol in a computer-simulation: (1) Actors may try to illegitimately use media while still using the protocol or (2) deny to follow the interaction-protocol altogether. In the sociological analysis it is regarded to be necessary to stick to the protocol in general, in order not to drop out of society. We suggest to study in the first place the effects of a legitimate and orderly use of Generalised Media of Interaction.

8 Perspectives on weak Socionics

In the scenario of Section 5 we assumed that all members of the agricultural society always accept guidelines coming from the representative. Obviously this is not very realistic. Social simulation might fail due to this architectural drawback of the presented mechanism. In the sense of weak Socionics, Computer Science can profit from Sociology through the introduction of Generalised Media of Interaction to the system as we describe now.

The concept of a currency has already been introduced to the system and can therefore easily be used as a Generalised Medium of Interaction: If a farming agent is not willing to accept production limitations, the representative can transfer money in order to compensate profit loss. This phenomenon occurs also in the „real world“ and is known as subsidising.

Similar to an attribute **money** attributes **power**, **influence,** and **commitment** can be associated with society members. A powerful representative can force farmers to behave in a desired fashion by threatening with negative sanctions (e.g., higher taxes) or supporting farmers. Adding other media than just money to control a MAS would allow for a more flexible structure.

9 Conclusion and Future Work

In this paper, we have presented two concepts, Generalised Media of Interaction and Abstract Resources, stemming from two sciences, Sociology and Computer Science. We have presented how one concept can be used to implement or refine the other. In order to clarify our ideas, we have related both concepts to a common domain, the Settlers' World.

Future work will focus on further elaborating on the differences and common grounds of the two concepts and on the application on more complex and realistic domains. In some cases, the representative loses amounts of Generalised Media of Interaction (in particular money); therefore from this perspective, Generalised Media of Interaction can be regarded as Abstract Resources. Obviously, not only the representative can make use of his Generalised Media of Interaction, but also the farmers might use them against the representative: e.g., a rich farmer might not care for the representative's punishments. Such relations will be interesting issues for future investigations, in Computer Science as well as in Sociology.

10 Acknowledgements

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